MANUFACTURING METHOD FOR A SEMICONDUCTOR DEVICE

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a manufacturing method for a semiconductor device, in particular, a manufacturing method for a device having silicon oxide films with at least two different thicknesses, which includes a process for improving a reliability of the silicon oxide film.

2. Description of the Related Art

Up to now, in manufacturing a MOS transistor having gate oxide films with two different thicknesses on a semiconductor substrate, the following processes have been adopted for improving the reliability of one of the gate oxide films.

First, as shown in Fig. 2A, an element isolation film 10 is formed on a silicon semiconductor substrate 9 using any well-known technique. After that, a first gate oxide (insulating) film 11 is formed, for example, through thermal oxidation of the silicon substrate. Active regions are formed in two or more regions owing to existence of the element isolation film 10.

Next, as shown in Fig. 2B, the first gate insulating film 11 is subjected to nitriding. In general, through the nitriding, nitrogen is segregated at an interface between the silicon substrate and the gate oxide film as a silicon oxynitride 12 to cover an interface

state or a trap, resulting in an improved reliability of the first gate insulating film.

Subsequently, as shown in Fig. 2C, a mask member 13 used for opening at least a portion where a second gate oxide film is to be formed is made of, for example, a photoresist film using any well-known technique. Thereafter, the first gate oxide film is selectively removed.

In general, the removal of the first gate oxide film is made using hydrofluoric acid. The application of hydrofluoric acid alone is insufficient for removing the silicon oxynitride (film) 12 formed at the interface between the silicon substrate and the gate oxide film. As a result, the silicon oxynitride 12 remains on the silicon substrate surface.

Next, as shown in Fig. 2D, the mask member 13 is removed, followed by forming a second gate oxide film 14, for example, through the thermal oxidation of the silicon substrate.

Subsequently, as shown in Fig. 2E, a gate electrode film 15 and source/drain 16 of a transistor are formed using any well-known technique. Through the above processes, the MOS transistor is manufactured.

According to a conventional manufacturing method, the second gate oxide film is formed while the silicon oxynitride formed upon nitriding the first gate oxide film remains on the silicon substrate surface. As a result, in the case of forming the second gate oxide

film, in particular, through the thermal oxidation, the silicon oxynitride acts thereon as an inhibitor against the oxidation, which causes such a problem as a remarkable deterioration in reliability of the second gate oxide film.

SUMMARY OF THE INVENTION

The present invention has been made in terms of the above-mentioned problems and an object of the present invention is to improve a manufacturing method and solve the above-mentioned problems.

According to the present invention, when a first gate insulating film is removed for forming a second gate oxide film or when a silicon substrate is washed just before the formation of the second gate oxide film, a manufacturing method includes treatment with an ammonia-hydrogen peroxide solution, whereby a silicon oxynitride film at a site where the second gate oxide film is to be formed can be removed prior to the formation of the second gate oxide film.

BRIEF DESCRIPTION OF THE DRAWINGS

In the accompanying drawings:

Figs. 1A to 1E are sectional views of an embodiment of the present invention in a step order; and

Figs. 2A to 2E are sectional views of the prior art in a step

order.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Hereinafter, an embodiment of the present invention will be described with reference to Figs. 1A to 1E. First, as shown in Fig. 1A, an element isolation film 2 is formed on a silicon semiconductor substrate 1 using any well-known technique. After that, a first gate oxide film 3 is formed, for example, through thermal oxidation of the silicon substrate. Semiconductor active regions are formed in two or more regions apart from one another owing to existence of the element isolation film 2.

Next, as shown in Fig. 1B, the first gate insulating film 3 is subjected to nitriding. In general, through the nitriding, nitrogen is segregated at an interface between the silicon substrate and the gate oxide film as a silicon oxynitride 4 to cover an interface state or a trap, resulting in an improved reliability of the first gate insulating film. In addition, a dinitrogen monoxide gas or an ammonia gas is used for nitriding. In particular, in the case of using the ammonia gas, higher activity can be achieved and thus, more silicon oxynitrides can be readily formed at the interface as compared with the dinitrogen monoxide gas.

Subsequently, as shown in Fig. 1C, a mask member 5 used for opening at least a portion where a second gate oxide film is to be formed is made of, for example, a photoresist film using any

well-known technique. Thereafter, a part of the first gate oxide film in the active region is selectively removed. In general, the removal of the first gate oxide film is made using hydrofluoric acid. The application of hydrofluoric acid alone is insufficient for removing the silicon oxynitride (film) 4 formed at the interface between the silicon substrate and the gate oxide film. To cope therewith, treatment with chemicals containing ammonia-hydrogen peroxide is added to the process for removal. The ammonia-hydrogen peroxide solution has an etching property against silicon or silicon nitride and thus, serves to remove the silicon oxynitride 4 as well.

Alternatively, when the first gate oxide film is selectively removed, the treatment with the hydrofluoric acid is solely performed as in the conventional method. Thereafter, at the time of washing the silicon substrate just before the second gate oxide film is formed, the treatment with the chemicals containing ammonia-hydrogen peroxide is added, which can provide the same effects.

Next, as shown in Fig. 1D, the mask member 5 is removed, followed by forming a second gate oxide film 6, for example, through the thermal oxidation of the silicon substrate 1. At this time, no silicon oxynitride serving as an inhibitor against the oxidation remains on the silicon substrate surface on which the second gate oxide film is formed. Thus, the high-quality gate oxide film can be formed.

Subsequently, as shown in Fig. 1E, a gate electrode film 7

and source/drain 8 of a transistor are formed using any well-known technique. Through the above processes, the MOS transistor is manufactured.

Hereinabove, given as the embodiment is the MOS transistor in which the first and second oxide films are both used as the gate oxide films. Needless to say, however, the present invention is applicable to the following manufacturing methods for the device and the same effects can be obtained.

1. A manufacturing method for a semiconductor device in which the first oxide film is used as an insulating film of a MOS capacitor element, whereas the second oxide film is used as the gate oxide film of the MOS transistor.

2. A manufacturing method for a semiconductor device in which the first oxide film is used as the gate oxide film of the MOS transistor, whereas the second oxide film is used as the insulating film of the MOS capacitor element.

3. A manufacturing method for a semiconductor device in which the first and second oxide films are both used as the insulating films of the MOS capacitor element.

According to the present invention, as set forth, the silicon oxynitride formed after nitriding is removed from the portion where the second gate oxide film is formed and hence, no inhibition occurs against the oxidation upon the formation of the second gate oxide film, whereby the reliability of the second gate oxide film can

be kept high.